A Finite Element Model for TBC Damage Detection and Lifetime Prediction

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Abstract: Thermal Barrier Coatings (TBC) have been used for almost three decades for heat insulation in high-temperature components to increase efficiency. Reliable diagnostic techniques that are practical to implement are needed to identify the location and severity of degradation in TBCs to protect against premature TBC failure. Luminescence spectroscopy has been utilized in detecting early damage, as it exhibits monotonic changes in the spectral characteristics with damage. Nevertheless there is still no agreement on what are the best spectral parameters that indicate damage. A new Finite Element model is presented, which is used to make realistic predictions of TBC lifetime, from as-manufactured to critically damaged. The aim of the modelling is to accurately incorporate all observed behaviour for a specific coating while retaining computational feasibility. To simulate damage accumulation and delamination the finite element model has been used to run several thermal cycles during which nucleation, propagation and coalescence of cracks is incorporated. A variety of cracking scenarios have been studied. The stress field of the oxide layer determined by the finite element model is subsequently converted into luminescence spectrum. Each stress level is represented by a Gaussian-Lorentzian shape function and by adding all the different stresses within the probed volume, the whole spectrum is obtained. The predicted luminescence spectrum for several cracks is used to identify characteristic spectral features that can be employed to predict TBC lifetime.

Keywords: Thermal Barrier Coating, Life Prediction, Oxidation, Residual Stress, and Luminescence Spectroscopy.

1. Introduction

Progress in aero-engines and land-based gas turbines is continuously linked with a rise of the operating temperature. In the next generation of advanced engines, further increases in thrust-to-weight ratio will require even higher gas temperatures. This means that the surface temperatures of the components will increase. Thermal barrier coatings (TBCs) have become a critical technology

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